Ontology-Based Approach for Interactive Virtual Object Generation

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1. Introduction

Recently, virtual reality has become popular as a human-computer interface paradigm. At ATR, we have been researching the subject of "Communication with Realistic Sensations" [1], which fits in this paradigm. This paper is based on the point of view that, although manipulation and representation have been the central issues of virtual reality research, the bottleneck lays in the difficulty of generating and modifying virtual objects interactively. Hence, there is a need to provide a means for virtual environment participants (e.g., a team of automobile designers) to create and modify, virtual objects in *real-time*, in a *realistic* manner to convey ideas that may be difficult to express otherwise. For instance, we consider it "realistic" to describe modification of an automobile model by placing one's hand in front of its virtual image and saying "elongate to here" or by stretching the object with both hands. We have achieved some results for manipulation of virtual objects and scenes with hand gestures and natural-like language (NLL) [2]; however, this paper contributes further by introducing the idea of *geometric*, *visual*, *qualitative* and *functional* concept sets, i.e. ontologies, to describe virtual objects and the actions performed on them. Based on these ontologies, the paper proposes an interactive approach for virtual object generation, manipulation and modification with NLL, hand gesture and 2D sketch input and describes an architecture for its implementation.

2. Virtual object generation, manipulation and modification based on conceptual abstractions

We claim that conceptual abstraction of at least some constrained range of real objects can provide the means to generate, manipulate and modify virtual objects via NLL. Previous research has proved the usefulness of ontologies, which capture abstract concept sets of a specific problem solving task, for mapping individual intentions expressed at the knowledge level to machine understandable forms [3 & 4]. We suggest that it is possible to extend the coverage of such concepts to include geometric, visual, qualitative and functional features.

A second claim we make is that transformation of hand gestures and 2D sketches into virtual objects can be attained if geometric concepts are coupled with NLL descriptions of the 2D sketches and the actions performed on them with our hands. Various approaches have attempted to transform 2D drawings into 3D models [e.g., 5 & 6], however, few efforts have attempted to aid the transformation and manipulation with NLL instructions [2 & 7]. Hence, it has been necessary to depend exclusively on geometric information, thus ignoring the wealth of descriptive information obtained from natural languages.

We have developed an approach for virtual object generation, manipulation and modification that takes into consideration these claims. The basic steps for the approach are described as follows:

1) Identify concepts related to virtual object generation, manipulation and modification with extended (to cover more than just symbolic knowledge) knowledge acquisition techniques such as repertory grids [8] or cataloguer/browser [9] to create a multi-layered ontology.

2) Index objects and operations performed on objects to those concepts identified in step 1.

3) Index hand gestures, which complement NLL descriptions of 3D objects or 2D sketches and actions performed on them, with concepts identified.

4) These processes are performed by various individuals with different backgrounds to allow generalization of the concepts and variety in the labels that represent them. The results are stored and maintained in a concept database.

5) Based on the concept database and indices at-

tached to the concepts, perform analogical reasoning to interpret a given participant's intentions from a particular interaction with the computer.

3. Architecture of a virtual object generation system

Figure 1 describes the architecture of an Ontology-based Virtual Object GENerating SYStem (OVO-GENESYS) currently being developed, which implements the approach described above. It is composed of the following.

Concept Database: comprises concepts, which may or may not be hierarchical. Each concept may be associated with one or more labels. Concepts are classified in four groups: state descriptors, feature descriptors, state operators and feature operators. Features may be geometrical (e.g., round), visual (e.g., color), functional (e.g., for sitting down) quantitative (e.g., size) or qualitative (e.g., large). Similarly, states may be quantitative positional (e.g., 50cm to the left) or qualitative positional (e.g., to the left of A).

Object Database: contains candidate 3D objects catalogued according to their type.

Natural Language Parser: uses labels mapped with concepts in the concept database as basic vocabulary.

Gesture Recognition Module: interprets hand gestures and movements.

Object Cataloguer/Browser: implements steps 1 through 5 of the approach described above.

Object Analogy Engine: parses a NLL phrase and searches in the concept database for an adequate state or feature descriptor/operator.

Object Modification Engine: parses NLL phrases and maps concepts which express object modification in terms of feature or state operators to specific actions on the objects. The operators are coupled with hand gestures for modification.

2D Sketch Understanding Module: allows the user to input 2D sketches of objects. Objects are then transformed into 3D representations with help of verbal descriptions of the object. The 2D sketch serves as the rough representation of the object, its spatial characteristics and its proportional geometry. The verbal description of the object is then mapped to state and feature descriptions and coupled with hand gestures similarly to the Object Modification Engine. The object analogy, modification engines and this module implement step 5 of our approach.

4. Conclusions

At present , OVO-GENESYS is still in its early development stage; therefore, it is not yet possible to say whether our ontology-based approach is indeed appropriate for virtual object generation. However, the approach is unique because it attempts to combine abstract concepts with NLL, hand gestures and 2D sketching to impart *realism* when generating, manipulating and modifying virtual objects. The system is being implemented on an Onyx RE^2 in C++ and CLOS with an initial database of automobiles.

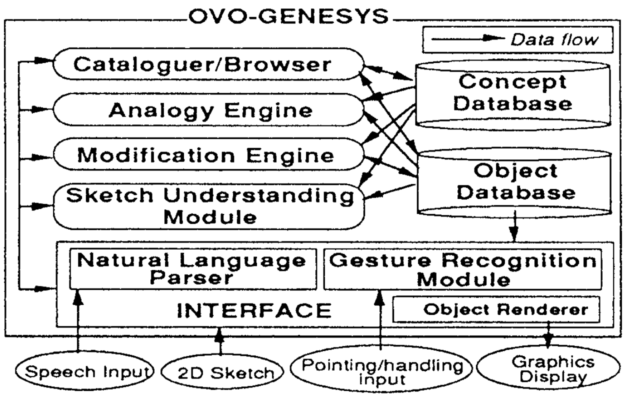

Figure 1. OVO-GENESYS's general architecture.

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